

# Development of Silicon Anode Materials for batteries

*To be the 1st European Silicon Anode player at scale*

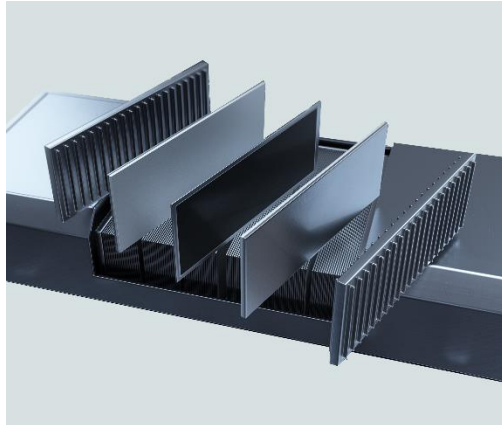
Let's  
go for  
zero

Net zero GHG. Zero regrets.  
Endless possibilities.

Jean-sebastien BRIDEL

# Who we are

## A global materials technology and recycling group



A global leader in automotive catalysts for internal combustion engines, hybrids and fuel cell powered vehicles



A leading supplier of key materials for rechargeable batteries used in electrified transportation and portable electronics



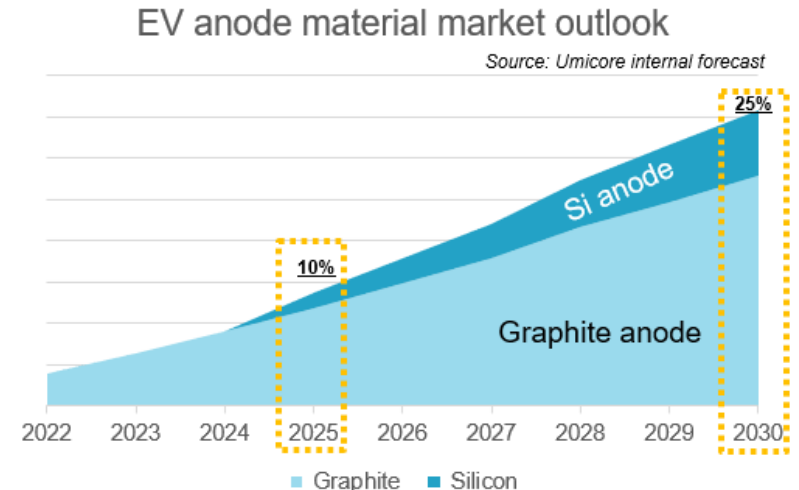
The world's leading recycler of complex waste streams containing precious and other valuable metals

# Si-anode growth outlook

# Si-anode growth outlook in EV application

## Fast growth backed by EV OEM roadmaps

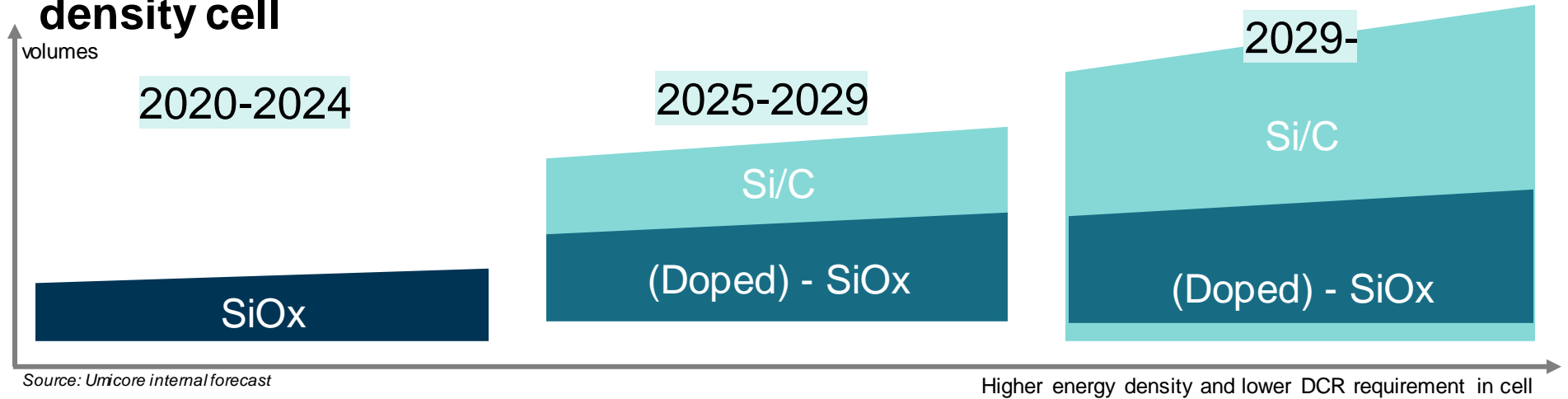
- Si-anode materials are in all **key OEM's roadmaps**
- Key driver: **higher energy density** and **fast charging**
- **SiOx has already been introduced** in limited amounts (max 5wt% e.g. Tesla, Porsche)
  - Higher energy density demands the use of **alternative technologies**, such as pre-lithiated SiOx or Si/C.
- Major growth in xEV expected as of 2025 driven by increasing adoption of Si-anode and its increasing content (%) in the cell
- Growth outlook consensus
  - **Si-anode share: +10% in 2025 and +25% in 2030**
  - CAGR silicon anode: +35% from 2022 to 2027
- More growth potential when/if Si-anode can be adopted not only in premium segment but in mass segment





# Si-anode outlook

**Si/C has the potential to gain significant share of the EV market, driven by \$/kWh requirements in higher energy density cell**



## **Phase 1: Si-anode starts, with SiOx dominating**

- Conventional SiOx: limited increase in energy density

## **Phase 2: higher energy density challenges SiOx**

- 2 options co-exist: Si/C and doped SiOx (Li-SiOx = increased cost, decreased capacity)

## **Phase3: SiC becomes dominant**

- Si/C becomes the leading technology with better performance and competitive cost



# What EV customers want and How Umicore answers them

# What EV customers want

## Key 5 factors



### Technical performance

- Swelling
- 1CE
- Rate capability
- Cycle performance
- Storage



### Competitive Cost (TCO perspective)

- Process cost
- Raw material cost
- High yield



### Production scalability

- Low CAPEX
- Easy access to equipment / machinery
- Legislation compliance



### Intellectual Property

- Freedom to Operate
- Geographical coverage

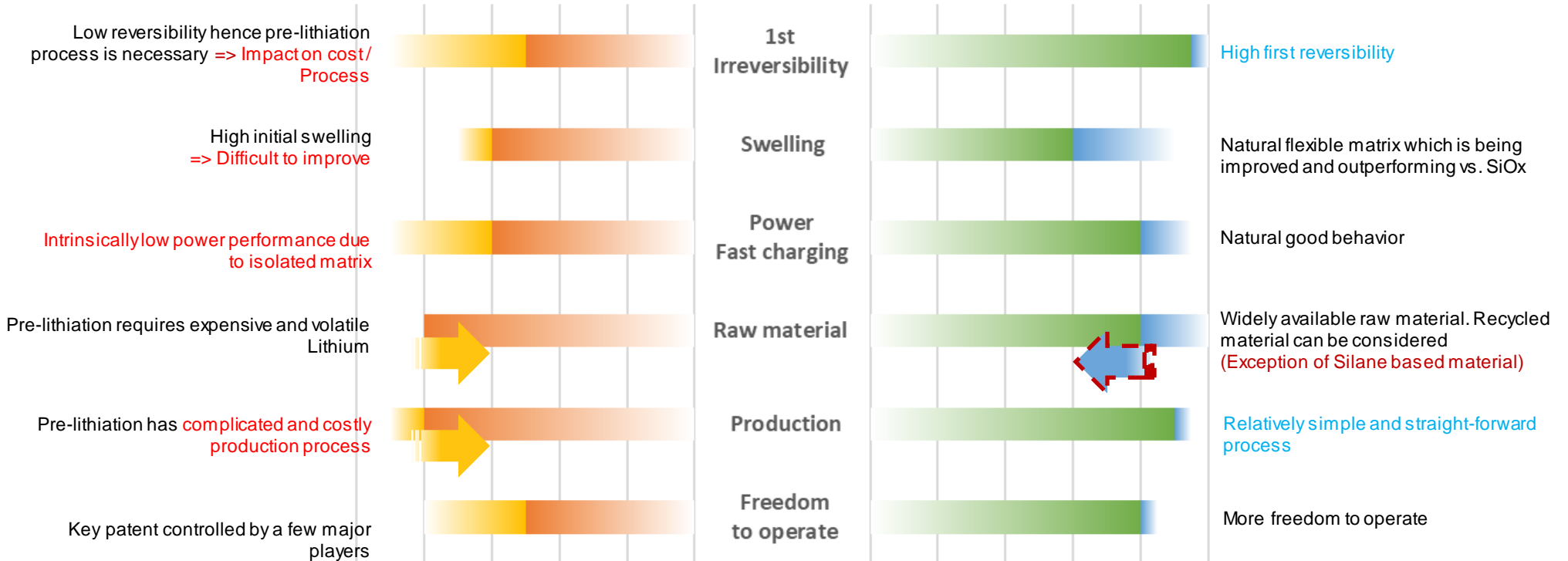


### ESG & LCA

- Low CO2
- Green energy source
- ESG compliance

# How to answer requirements?

## SiOx or Si/C



Confirmation of the trend toward Si/C



# Umicore unique value propositions

## 5 key differentiating factors



### Technical performance

- Umicore Si/C performance confirmed by several EV customers (Battery makers and OEMs)
- Particularly the best in class in swelling, rate performance, 1CE and cycle life



### Price

- Best \$/kWh from abundant raw material, scalable process and the technical advantages (e.g. 1CE, swelling, rate capability)



### Production scalability

- Scalable process based on proven and already used building blocks vs. other technologies
- Easy access to all equipment and machineries



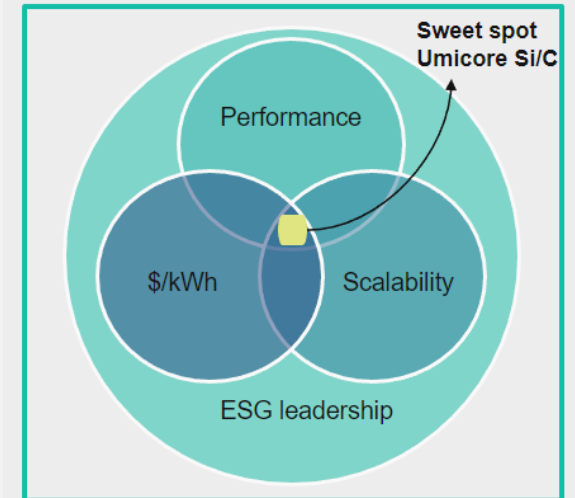
### ESG

- Green energy source
- Potential of European supply chain integration by partnership

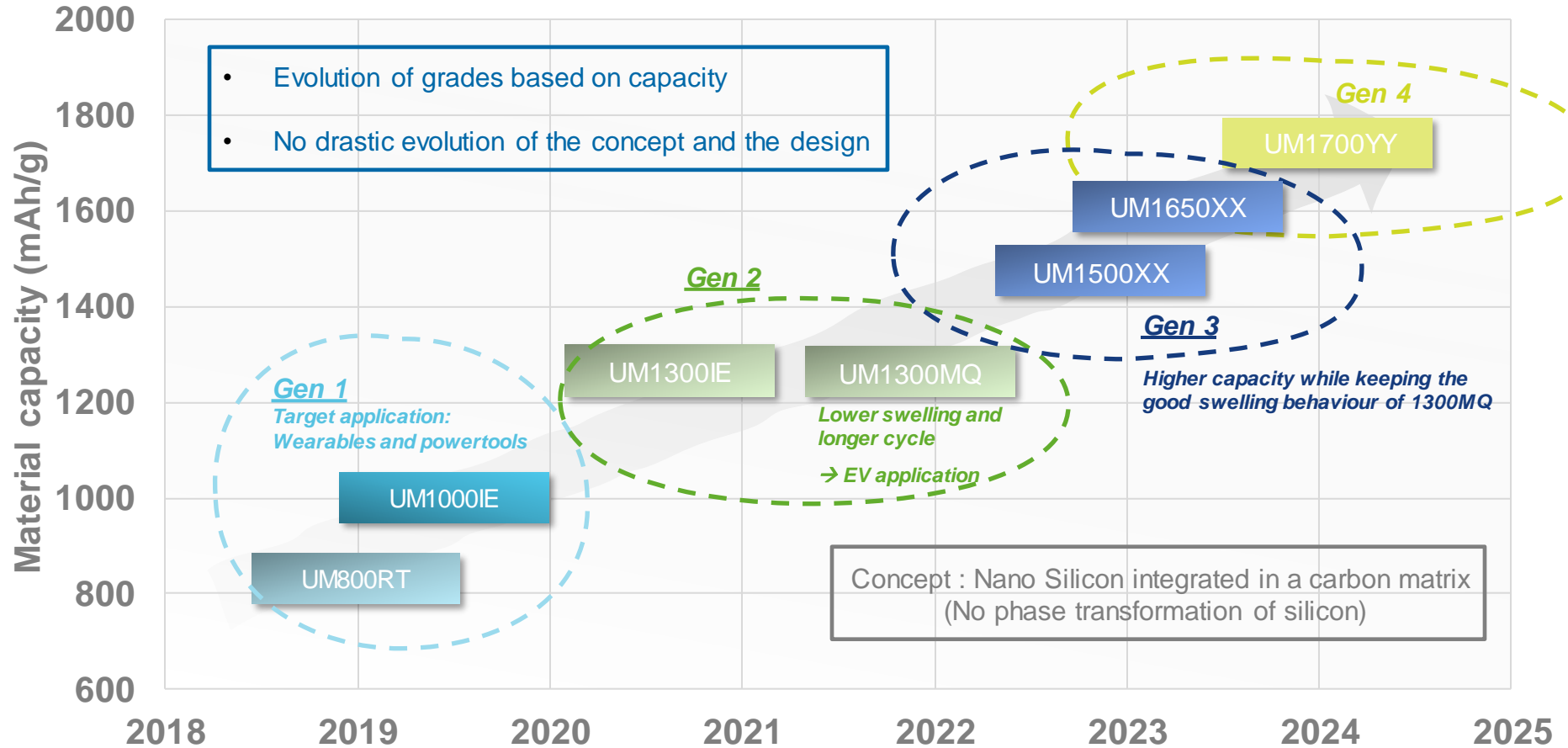
### IP

- Strong IP portfolio with over 200 patents in 39 patent families
- Ranked global No.4 among material providers in Anode IP strength index by Know made

### IP Protection



# R&D roadmap at Umicore

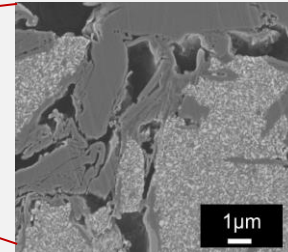
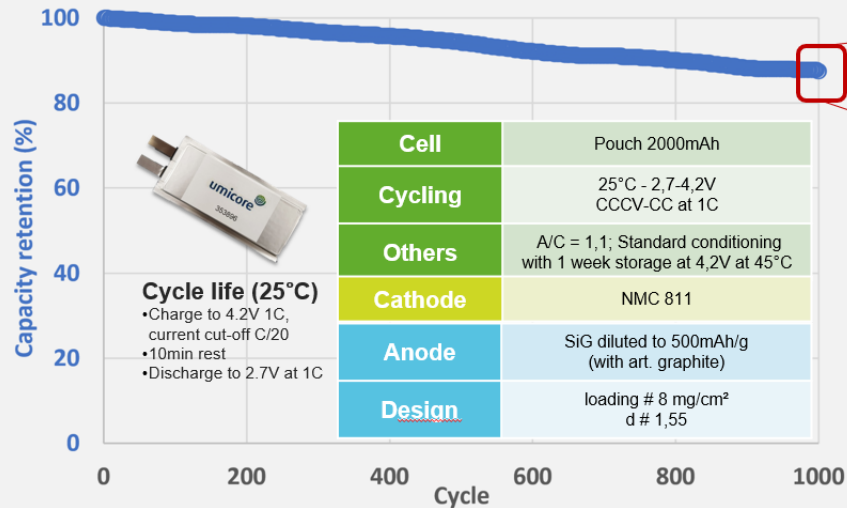


# Internal test result of UM1300MQ

## Excellent cycle life due to low swelling



- Energy density: +90% 1CE (1.5V), no doping / pre-lithiation required
- Top of class on swelling
- Fast charge: excellent power behavior and low DCR
- Good storage behavior
- Easy cell integration



**+800 cycles at 90% retention (25°C)**  
**>1600 cycles at 80%**

- Limited swelling thanks to the adaptative carbon matrix
- No particle cracking
- Stability from the engineered interface between Si and C matrix

**Key EV customers are confirming / overachieving the internal test result**



# • Way forward

# Umicore Si/C : Way-forward



## Focusing on strategic regions and value chain integration

### Performance

- Umicore Si/C performance confirmed by several EV customers
  - Continued R&D into next generation materials and collaboration with key customers
- 

### Developing industrial-scale production capabilities

- Focus on Europe:
    - Legislation compliance
    - Green energy source
    - Cost benefit
    - Proximity to customers and raw materials
- 

### Value chain integration

- Focus on strategic partnership with European suppliers to complete European key material value chain integration
- Potential to expand the model to other strategic region such as North America

- Conclusion



# Key takeaways

Si-anode are expected to grow massively driven by high energy density and fast charging requirement.

Si/C has the potential to gain significant share of the EV market

EV customers 5 key needs:  
Performance, Cost, Scale, IP, ESG  
→ Umicore Si/C business value proposition and differentiating factors

Umicore Si/C performance being confirmed by several EV customers

Umicore is preparing the next step to industrialize its Si/C materials for EV customers

***To be the 1st European Silicon Anode player at scale...***



materials for a better life

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